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ASSESSMENT OF THE EFFECTS OF CEILING-MOUNTED DESTRATIFICATION FANS ON THE PERFORMANCE OF "PRODUCTS OF COMBUSTION" TYPE FIRE DETECTORS

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The introduction of ceiling mounted destratification fans into rooms protected by "products of combustion" type fire detectors will reduce the effectiveness of these detectors. This report documents the tests, test results and recommendations concerning the effects of ceiling mounted destratification fans on "products of combustion" type fire detectors arising from the experiments and data analysis performed at the Naval Civil Engineering Laboratory under sponsorship of the U.S. Air Force Engineering and Services Center.

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The results of the tests performed show two distinct effects produced by the introduction of the destratification fans into the test facilities. Most clearly, the delay between the ignition of the fuel and the response of the detectors was increased by an average 16.2 seconds. As was to be expected, the detectors located closest to the smoke source were in general the first to signal alarm.

The second effect of the fans is a decrease in the number of responding detectors. This effect can be explained by considering the limited output of the smoke source and the porous construction of the test facility. In a semi-porous building, such as a typical restaurant or club, some of the smoke is vented through open windows, doors, and forced ventilation systems. This complication can lead to an equilibrium situation in which the rate at which smoke is produced by the fire is marched by the rate of smoke dissipation through the various vents. The equilibrium concentration will be lower when the room has ceiling fans operating in it because smoke that would normally be isolated from the effects of ventilation will be mixed into the moving air by the circulating effects of the fans. Thus, the probability of a fire going undetected is greater.

The data gathered suggests that ceiling destratification fans increase the response time for "products of combustion" type of fire detectors. The magnitude of this increase is dependent on size of the fire, the distance between the fire and the detector, and the number of fans operating per unit area. This data also indicates that the number of responding detectors is reduced considerably, especially during the early stages of the fire in areas that are being destratified with ceiling fans. Since it is impossible to predict exactly where a fire will break out, we cannot reliably reduce the effects of these fans by minimizing the distance between the detectors and the smoke source except by increasing the concentration of detectors in the room. Fortunately, except for the very early stages of the fire, the delay produced by the fans is minimal for detectors near the smoke source. It is therefore the recommendation that the area covered per detector in a room equipped with ceiling mounted destratification fans be reduced approximately 50 percent. This will reduce the likelihood of a fire being masked by the fans operating in the room.

PREFACE

This report was prepared by the Naval Civil Engineering Laboratory, Port Hueneme CA for the Headquarters Air Force Engineering and Services Center, Engineering and Services Laboratory, FY83 Investigational Engineering (IE) Program, under MIPR 83-59. This report summarizes work done between April 1983 and September 1983. Capt Fred K. Walker was the Project Officer.

This report has been reviewed by the Public Affairs Office (PA) and is releasible to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

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SECTION I

INTRODUCTION AND BACKGROUND

A. INTRODUCTION

It has been suggested that the introduction of ceiling-mounted destratification fans into rooms protected by "products of combustion" type fire detectors may reduce the effectiveness of these detectors. This report documents the tests, test results, and recommendations concerning the effects of ceiling-mounted destratification fans on "products of combustion" type fire detectors arising from the experiments and data analysis performed at the Naval Civil Engineering Laboratory (NCEL), under sponsorship of the Air Force Engineering and Services Center through MIPR No. N83-59. The expression "products of combustion" is used synonomously with the word "smoke" in this report.

B. BACKGROUND

The purpose of a destratification fan is to circulate or destratify the air in a room. Circulating the air in the room avoids the layering or stratification that naturally occurs from density differences in the air. This, in turn, prevents the temperature gradient between the floor and the ceiling from occurring, providing a more comfortable environment. Currently, ceiling destratification fans are commonly used in private homes, commercial and industrial complexes, restaurants and clubs, including Air Force clubs.

Recent advances in technology have produced small, self-contained smoke detectors that are accurate and reliable, if properly installed and maintained. These detectors can provide early warning of a fire, allowing more time for response before it becomes uncontrollable. Past research has shown that air flow in a room is an important parameter in determining the response time of a smoke detector. The other important parameter in fire detection is the concentration of the smoke. A minimum concentration of smoke must exist or there will be no alarm. In a room without destratification fans, the smoke emitted by the fire rises to the ceiling where it spreads out. To take advantage of this mechanism, smoke detectors are usually mounted on the ceiling where the smoke arrives first and has the greatest concentration. When ceiling destratification fans are introduced, this mechanism is essentially destroyed or, at least, greatly altered. The Air Force has requested NCEL to investigate and assess the effects of these fans on the response of smoke detectors and to identify criteria that will minimize these effects.

SECTION II

ACCOMPLISHMENTS

Extensive testing and statistical data analysis were performed at NCEL to qualitatively and quantitatively define the effects of ceiling-mounted destratification fans on "products of combustion" type fire detectors. The testing was conducted in a domed-ceiling concrete "burn building" with approximately 1,020 square feet of floor area. Four Sears three-speed, 52-inch ceiling fans were mounted to the ceiling so that the blades were approximately 10 feet off the floor. Eighteen BRK brand smoke detectors (nine ionization-type and nine photoelectric-type) were also mounted to the ceiling at various points relative to the fans and smoke source. Each of the detectors was wired to a "Visicorder" event-recording device which indicated the response of each detector against time. A photograph of the test facilities, fans, and detectors is shown in Figure 1. A photograph of the instrumentation is shown in Figure 2, and a schematic of the test facility is shown in Figure 3.

The test procedure was defined and testing was performed on three configurations: (1) with no fans operating, (2) with one fan operating, and (3) with four fans operating. The first configuration was the "control" test which defined standard response times and patterns (i.e., responses unaffected by fans). Configuration 2 was intended to demonstrate the effect of one fan. Configuration 3 was intended to demonstrate the effect of multiple fans.

The source of the products of combustion was a burning mixture of gasoline and oil. This source provided good repeatability but still allowed changes in burning time and rate to be made as desired. The smoke source was first positioned in the test facility, as shown in Figure 1. Initially, the tests were conducted, using 50 ml of the mixture of fuel to decrease the quantity of smoke released, possibly amplifying the effects of the fans, and better simulating the early stages of a fire. The mixture was measured out and placed in a metal pan, 16 inches in diameter. The recorder was then started and the fuel ignited. The data collected during the tests are shown in the appendix. The results of the statistical analysis of this data are shown in tabular form in Table 1 and in graphic form in Figures 4, 5, 7, 8, and 9.

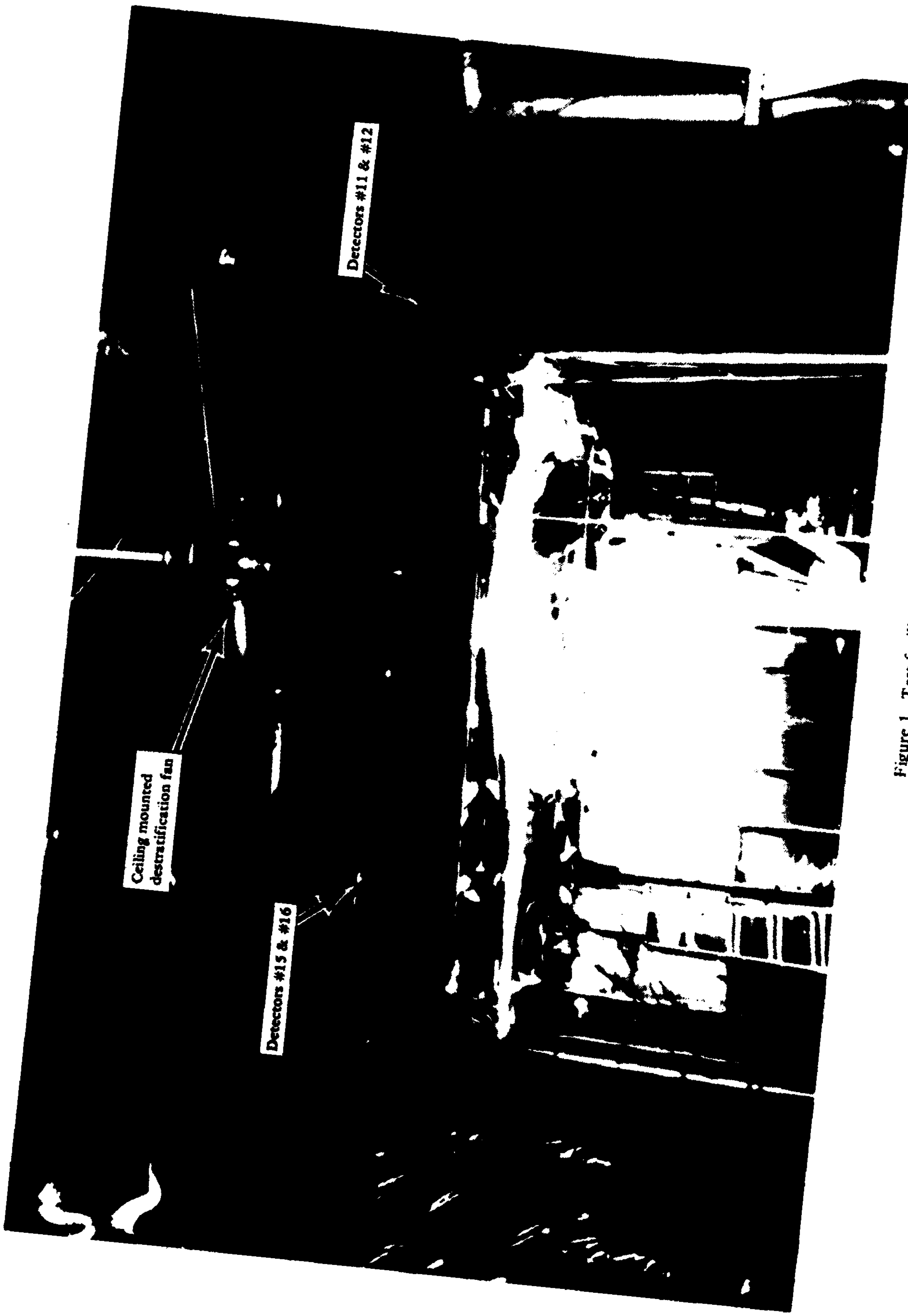


Figure 1. Test facility

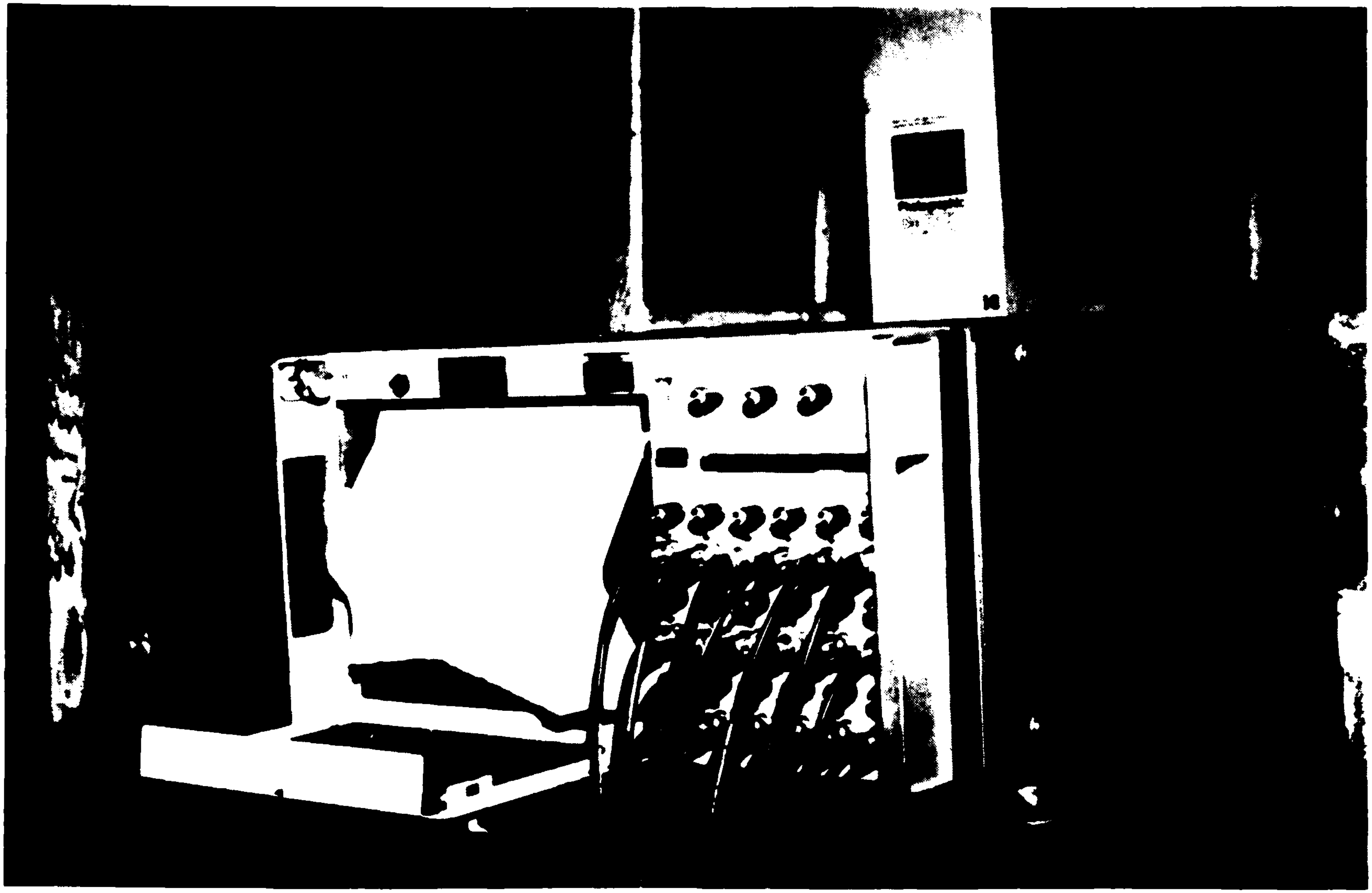
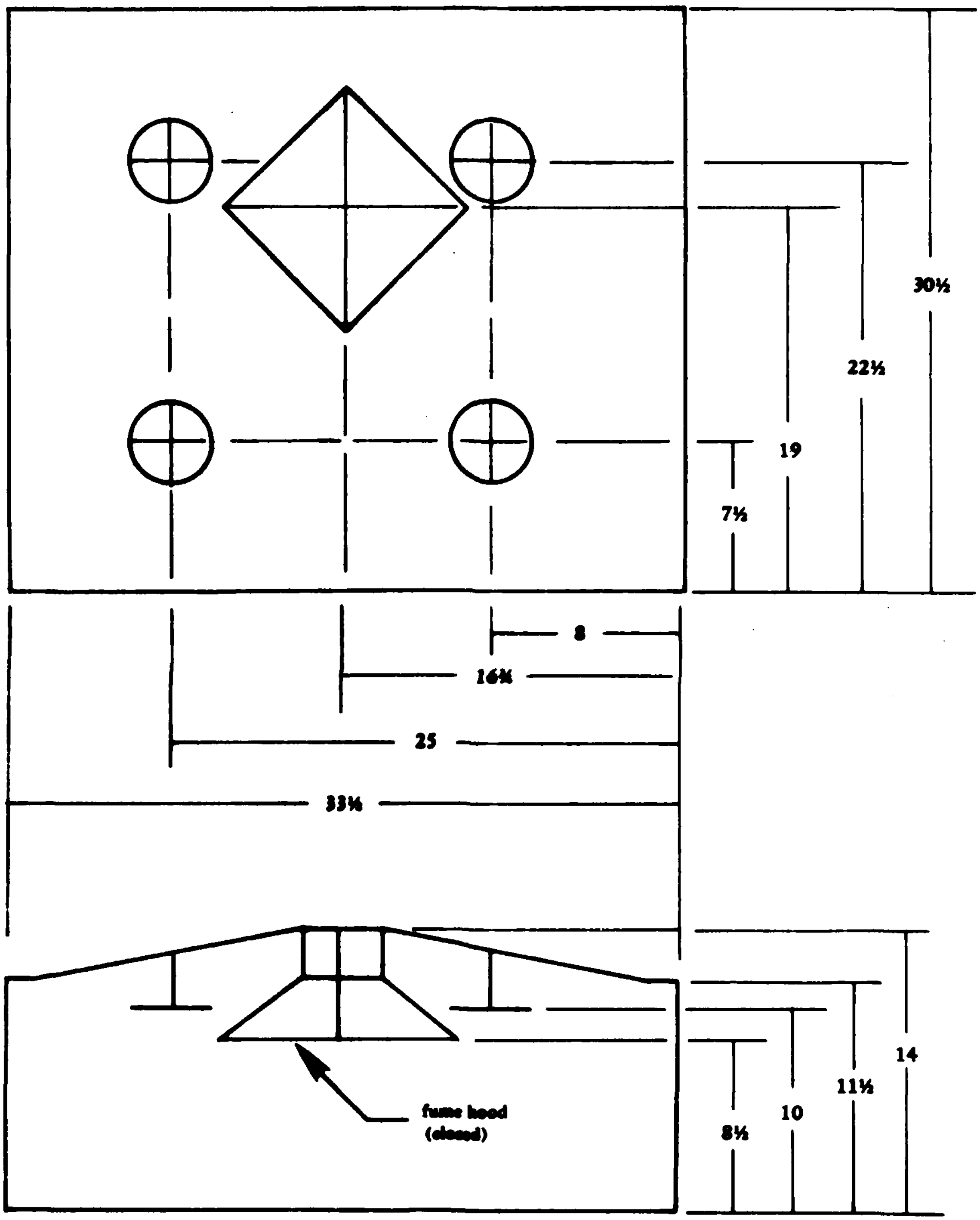


Figure 2. Instrumentation



All dimensions in feet

Scale: $\frac{1"}{8}$ = 1 ft.

Figure 3. Schematic of test facilities.

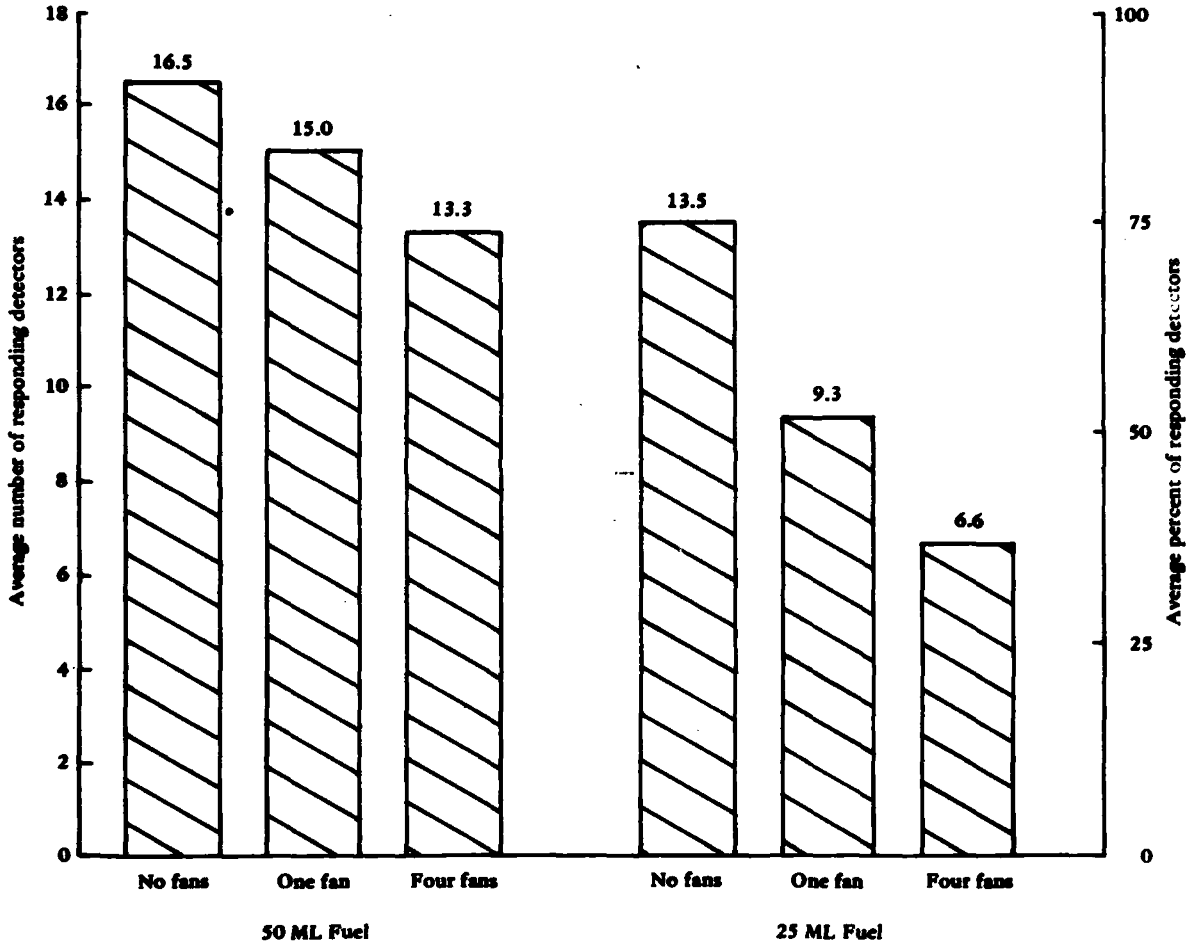


Figure 4. Average number of responding detectors.

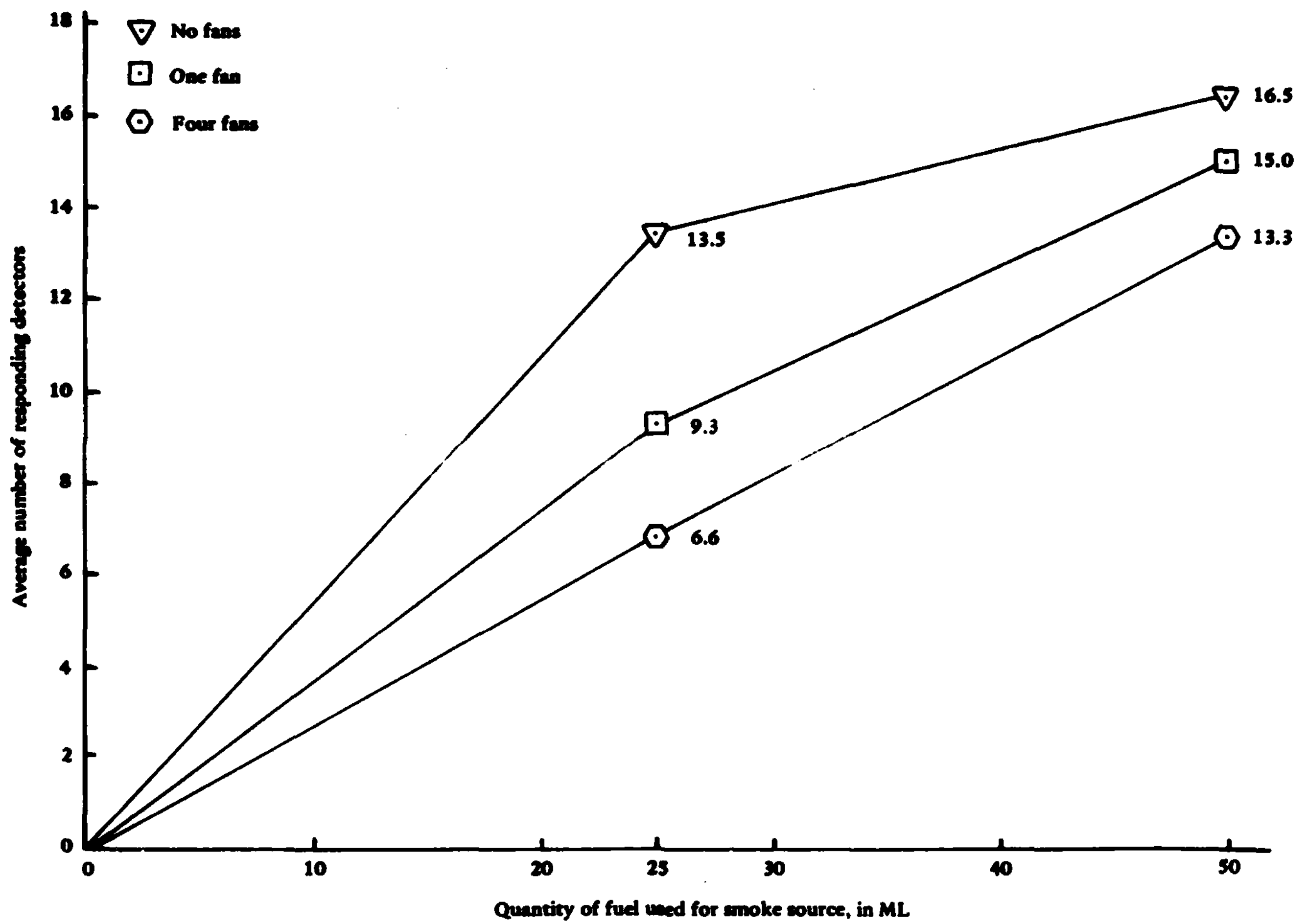


Figure 5. Number of responses versus quantity of fuel burned.

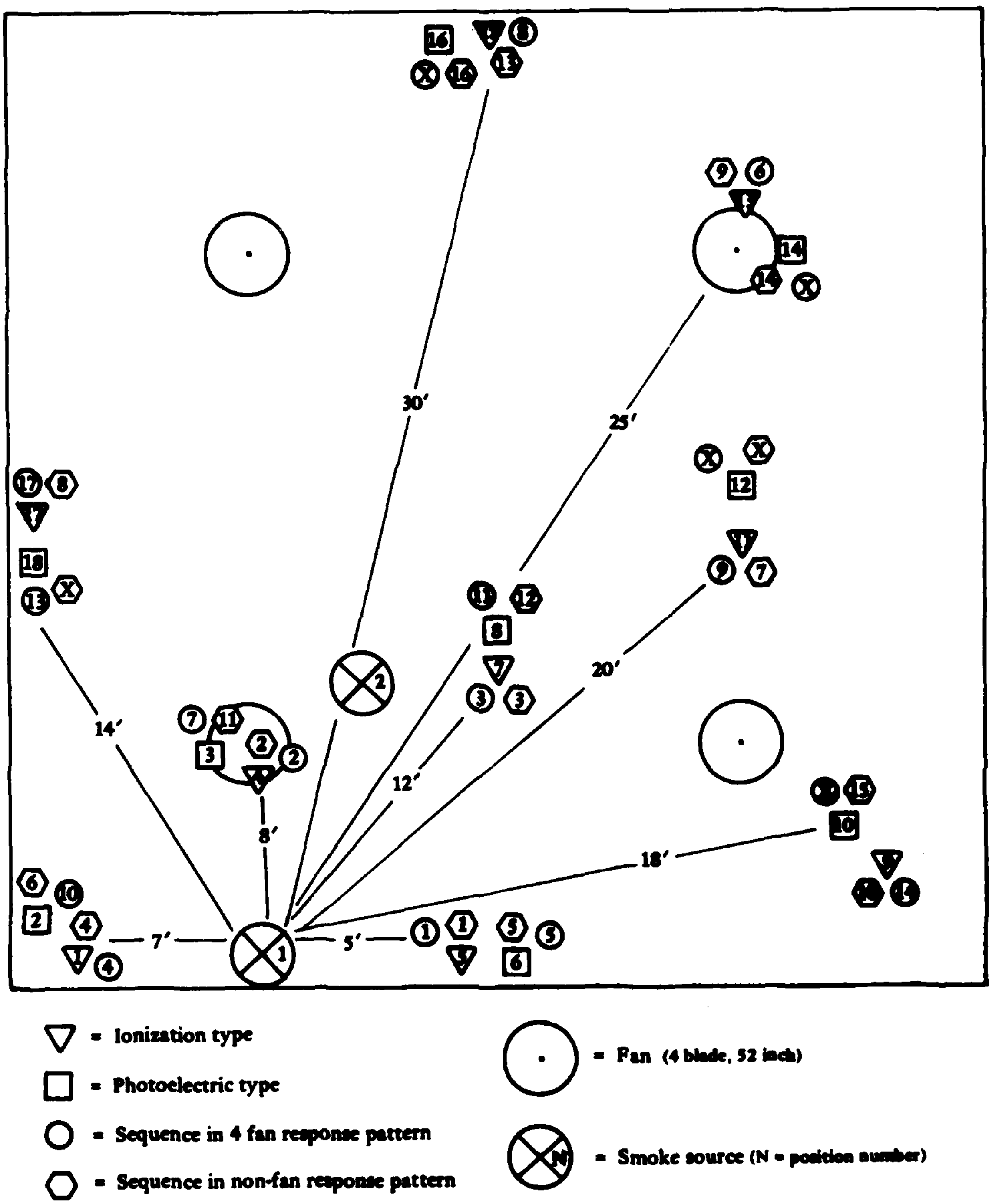


Figure 6. Average response patterns.

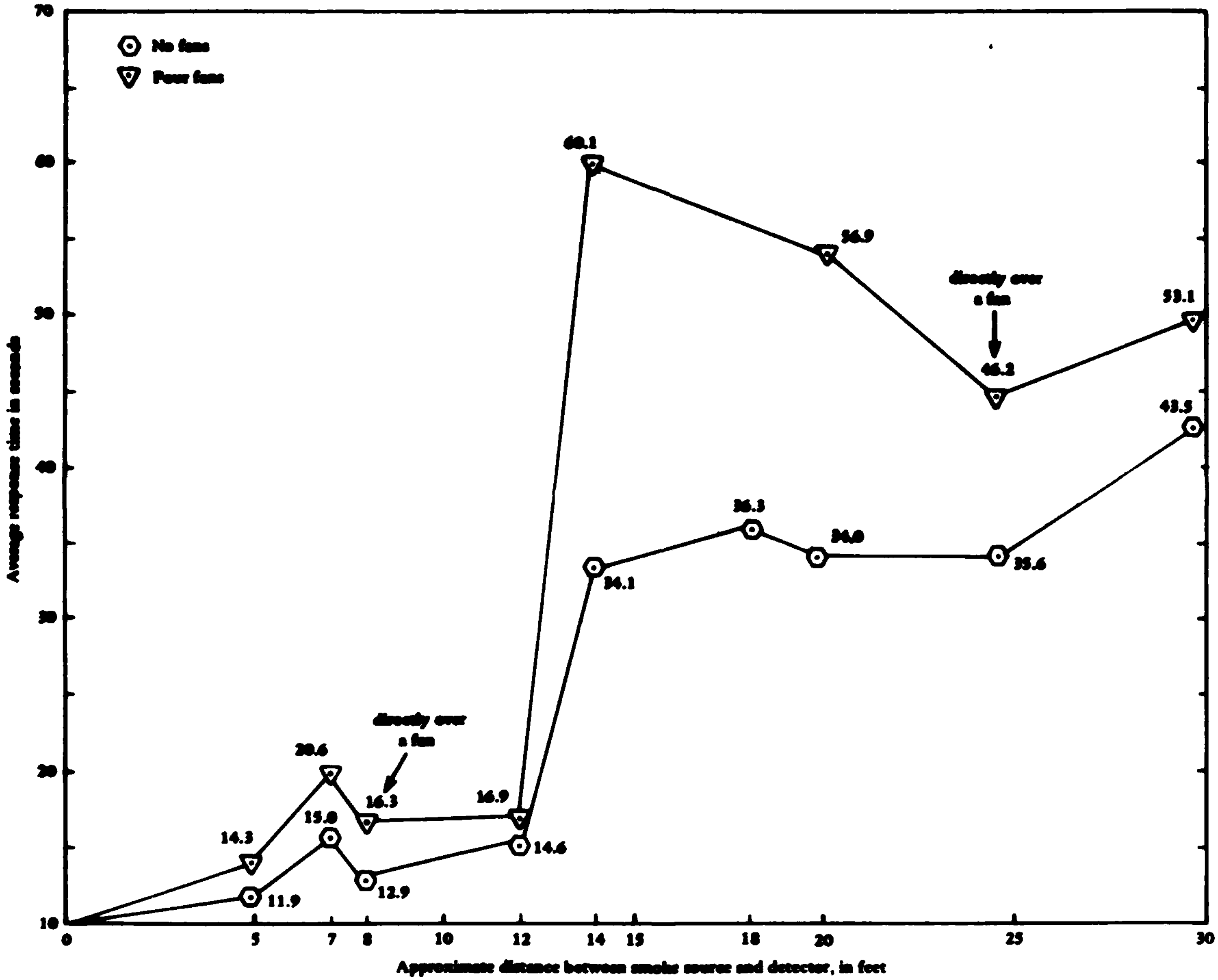


Figure 7. Average response time versus distance between detector and smoke source, 50 ML case.

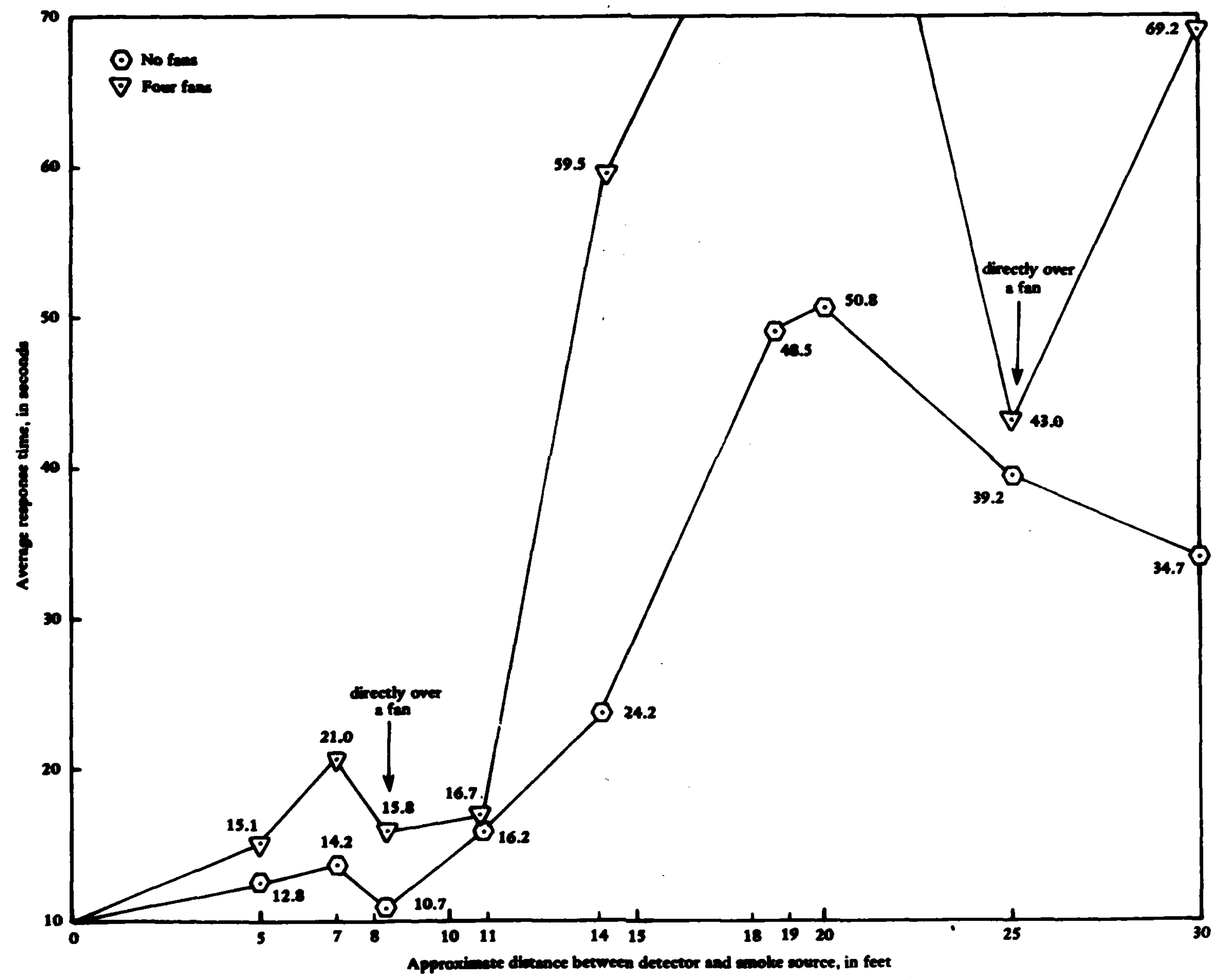


Figure 8. Average response time versus distance between detectors and smoke source, 25 ML case.

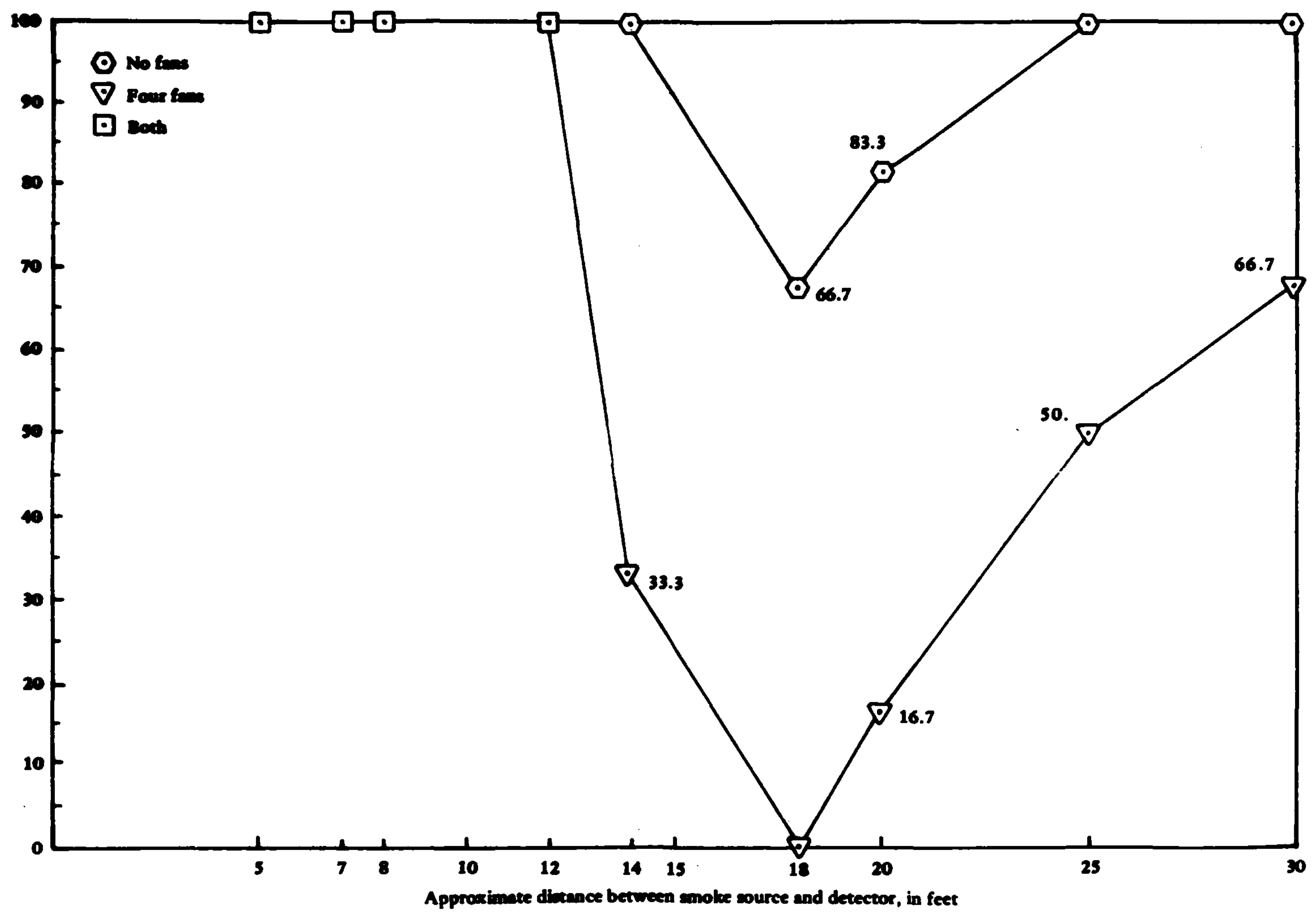


Figure 9. Probability of response versus distance between smoke source and detector, 25 ML case.

Table 1. Comparative Reduced Data Sheet

Detector Number	50 ml Fuel Tests						25 ml Fuel Tests					
	No Fans		One Fan		Four Fans		No Fans		One Fan		Four Fans	
	Avg Response Time (sec)	Percent Response	Avg Response Time (sec)	Percent Response	Avg Response Time (sec)	Percent Response	Avg Response Time (sec)	Percent Response	Avg Response Time (sec)	Percent Response	Avg Response Time (sec)	Percent Response
1	15.0	100	17.4	100	20.6	100	14.2	100	18.8	100	21.0	100
2	28.2	100	30.0	100	57.2	100	30.5	100	23.0	16.7	74.0	16.7
3	36.8	100	35.6	100	46.9	100	35.3	100	28.5	66.7	53.5	33
4	12.9	100	13.6	100	16.3	100	10.7	100	13.7	100	15.8	100
5	11.9	100	12.4	100	14.3	100	12.8	100	15.0	100	15.1	100
6	24.0	100	23.0	100	37.1	100	24.5	100	37.5	66.7	42.0	33
7	14.6	100	15.2	100	16.9	100	16.2	83.3	16.0	100	16.7	100
8	38.8	100	35.8	100	59.2	100	47.5	100	66.0	50	82.0	16.7
9	36.3	100	69.4	100	91.6	50	48.5	66.7	--	0	--	0
10	84.8	90	115.2	80	--	0	88.5	33.3	--	0	--	0
11	34.0	100	35.4	100	56.9	100	50.8	83.3	52.0	50	112.0	16.7
12	59.3	40	--	0	--	0	--	0	--	0	--	0
13	35.6	100	36.6	100	46.2	100	39.2	100	51.5	100	43.0	50
14	75.8	80	108.3	50	--	0	--	0	--	0	--	0
15	43.5	100	45.2	100	53.1	100	34.7	100	48.5	100	69.2	61.7
16	94.5	100	50.0	40	93.5	20	--	0	--	0	--	0
17	34.1	100	31.4	100	60.1	100	24.2	100	64.4	83.3	59.5	33.3
18	47.3	40	34.0	40	72.3	60	32.0	67	--	0	--	0
Overall Average*	28.1	91.7	30.8	83.9	44.3	73.9	24.2	75	26.9	51.7	38.5	36.7
Avg No. Responding Detectors	16.5 = 92%		15 = 83.3%		13.3 = 73.9%		13.5 = 75%		9.3 = 51.7%		6.6 = 36.7%	
No. of Detectors Meeting Overall Average Criteria	16		15		13		16		12		6	

*The overall average includes only those average response times for the detectors that responded at least 50% in all three categories.

SECTION III

DISCUSSION

The results of the tests performed show two distinct effects produced by the introduction of the destratification fans into the test facilities. Most clearly, the delay between the ignition of the fuel and the response of the detectors was increased by an average 16.2 seconds. As was to be expected, the detectors located closest to the smoke source were the first to signal alarm. A schematic of the average response patterns for Cases 1 and 3 (no fans and four fans, respectively) is shown in Figure 7. Careful inspection of the data shows that the longer the response time for detectors in Case 1, the greater the increase in response time for the same detector in Case 3 (see Figures 7 and 8).

The second effect of the fans is a decrease in the number of responding detectors. This effect is shown most clearly in Figure 4. This effect can be explained by considering the limited output of the smoke source and the porous construction of the test facility. In a semiporous building, such as a typical restaurant or club, some of the smoke is vented through open windows, doors, and forced ventilation systems. This complication can lead to an equilibrium situation in which the rate at which smoke is produced by the fire is matched by the rate of smoke dissipation through the various vents. If this equilibrium concentration is below the level recognized by the detectors, fewer, on possibly no alarms will result. The equilibrium concentration will be lower when the room has ceiling fans operating in it because smoke that would normally be isolated from the effects of ventilation will be mixed into the moving air by the circulating effects of the fans. Thus, the probability of a fire going undetected is greater. This effect was borne out by the data collected in both the 50 and 25 ml tests conducted at NCEL. For the 50 ml tests, Configuration 3 (four fans) had an average of 3.2 fewer responding detectors than did Configuration 1 (no fans). In the 25 ml tests, Configuration 3 had an average of 6.9 fewer responding detectors than Configuration 1.

The limited output smoke source allowed practical repeatability but restricted the tests to simulation of a fire at a single point of its life. Although this is not an ideal simulation, the effect of the fans on the detector operation was not changed. Rather, the data only give discrete points during the history of the fire. Extrapolation of the data from the 25 and 50 ml experiments further supports the idea that when the fire is small (in the time region when the fire being simulated would perhaps be modeled with less than 25 ml of fuel), the delay caused by the fans may be greater. Due to the limited scope of this project, however, tests to gather evidence to further support this extrapolation were not performed. Figure 5 shows this extrapolation.

The response patterns shown in Figure 6 show that the introduction of fans has minimal effect on the air flow patterns immediately around the fire, as evidenced by the similar patterns for the first five responding detectors in Configuration 1. As the distance between the smoke source and detectors is increased, however, this similarity in pattern is lost. This indicates that the effects of the fans on the air flow in the room depends on the number of fans and the distance between the smoke source and the detector.

The detectors that showed the least detrimental effects of the fans were those located closest to the smoke source, Numbers 1, 2, 3, 4, 5, and 6. However, the detectors which were located at the highest part of the facility, Numbers 7 and 8, also seemed little affected in the 50 ml tests. Detectors located directly over the fans seemed no more or less affected by the fan operation than did those at equal distances from the smoke source that were not over the fans. The data indicate that the response delay for these detectors is actually reduced slightly (see Figures 8 and 9). The detectors that seemed most affected by the fans were those located at low points of the ceiling away from the smoke source.

It was later speculated that the proximity of the smoke source to the wall of the test facility might have affected the data in such a way as to limit the generality of the results. Additional tests were run to address this question. The smoke source was moved away from the wall to Position 2 as shown in Figure 6. The results of those tests, although different in absolute terms from the previous data (as was expected), still supported the theory that the fans adversely affect the performance of the detectors. Similar increases in response delay and decreases in the number of responding detectors were noted when the fans were introduced to this arrangement.

SECTION IV

CONCLUSIONS

The data gathered suggest that ceiling destratification fans increase the response time for "products of combustion" type of fire detectors. The magnitude of this increase depends on the size of the fire, the distance between the fire and the detector, and the number of fans operating per unit area. These data also indicate that the number of responding detectors is reduced considerably, especially during the early stages of the fire in areas that are being destratified with ceiling fans. Since it is impossible to predict exactly where a fire will break out, we cannot reliably reduce the effects of these fans by minimizing the distance between the detectors and the smoke source, except by increasing the concentration of detectors in the room. Fortunately, except for the very early stages of the fire, the delay produced by the fans is minimal for detectors near the smoke source. Of perhaps greater significance is the reduced number of responding detectors in destratified rooms. This effect, too, can be somewhat compensated for by an increase in the concentration of the detectors. It is therefore the recommendation of NCEL that the area covered per detector in a room equipped with ceiling-mounted destratification fans be reduced approximately 50 percent. This will reduce the likelihood of a fire being masked by the fans operating in the room.

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Appendix A

TABULAR TEST DATA AND RESULTS

CUMULATIVE TEST DATA SHEET

Fan Speed: medium
No. of Fans: 4
Smoke Source: 25 ml gas
Size or Quan: large pan

Date Prepared: 7/20/83
Data Collected: 7/16 - 7/20

Test # →		18	19	20	38	39	23	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5	6			
1	I	20	21	28	18	19	20	21.0	3.6	100%
2	E	X	X	X	X	X	74	74	X	17%
3	E	X	50	X	X	X	57	53.5	4.9	33%
4	I	13	16	19	13	15	20	15.8	3.0	100%
5	I	16	16	15	13	16	15	15.1	1.2	100%
6	E	X	27	X	X	X	57	42.0	21.0	33%
7	I	15	17	18	16	18	16	16.7	1.2	100%
8	E	X	X	X	X	X	82	82	X	17%
9	I	X	X	X	X	X	X	X	X	0%
10	E	X	X	X	X	X	X	X	X	0%
11	I	X	X	X	X	X	112	112	X	17%
12	E	X	X	X	X	X	X	X	X	0%
13	I	X	47	X	X	40	42	43.0	3.6	50%
14	E	X	X	X	X	X	X	X	X	0%
15	I	X	36	51	X	91	99	69.2	30.5	67%
16	E	X	X	X	X	X	X	X	X	0%
17	I	X	X	X	X	44	75	59.5	21.9	33%
18	E	X	X	X	X	X	X	X	X	0%
Number of Resp. Detec.		4	8	5	4	7	12	6.6	3.1	36.7%

CUMULATIVE TEST DATA SHEET

Fan Speed: medium
No. of Fans: 1
Smoke Source: 25 ml gas
Size or Quan: large pan

Date Prepared: 7/26/83
Data Collected: 7/26

Test # →		55	56	57	58	59	60	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5	6			
1	I	19	15	18	19	24	18	18.8	2.9	100%
2	E	23	X	X	X	X	X	23	X	16.7%
3	E	37	X	31	25	X	21	28.5	7.0	66.7%
4	I	15	13	13	12	16	13	13.7	1.5	100%
5	I	18	14	14	16	14	14	15.0	1.7	100%
6	E	X	30	30	63	27	X	37.5	17.0	66.7%
7	I	19	14	15	16	16	16	16.0	1.7	100%
8	E	X	103	X	55	X	40	66.0	33	50%
9	I	X	X	X	X	X	X	X	X	0%
10	E	X	X	X	X	X	X	X	X	0%
11	I	81	X	40	X	X	35	52.0	25.2	50%
12	E	X	X	X	X	X	X	X	X	0%
13	I	40	43	65	70	38	53	51.5	13.5	100%
14	E	X	X	X	X	X	X	X	X	0%
15	I	40	31	32	34	82	72	48.5	22.5	100%
16	E	X	X	X	X	X	X	X	X	0%
17	I	33	68	84	73	58	X	64.4	20.2	83.3%
18	E	X	X	X	X	X	X	X	X	0%
Number of Resp. Detec.		10	9	10	10	8	9	9.3	--	51.7%

CUMULATIVE TEST DATA SHEET

Fan Speed: 0
No. of Fans: 0
Smoke Source: 25 ml gas
Size or Quan: large pan

Date Prepared: 7/20/83
Data Collected: 7/20 - 7/

Test # →		40	41	42	43	44	45	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5	6			
1	I	13	12	18	17	12	13	14.2	2.6	100%
2	E	24	25	22	32	53	27	30.5	11.5	100%
3	E	43	51	43	24	24	27	35.3	11.7	100%
4	I	10	10	13	14	8	9	10.7	2.3	100%
5	I	11	10	17	15	11	13	12.8	2.7	100%
6	E	23	28	27	21	24	24	24.5	2.6	100%
7	I	X	14	19	19	15	14	16.2	2.6	83.3%
8	E	50	66	27	45	34	63	47.5	15.5	100%
9	I	43	X	43	76	32	X	48.5	19.0	67%
10	E	103	X	74	X	X	X	88.5	20.5	33%
11	I	83	X	36	42	38	55	50.8	19.5	83.3%
12	E	X	X	X	X	X	X	X	X	0%
13	I	41	51	38	37	36	32	39.2	6.5	100%
14	E	X	X	X	X	X	X	X	X	0%
15	I	39	33	36	35	30	35	34.7	3.0	100%
16	E	X	X	X	X	X	X	X	X	0%
17	I	23	22	29	27	22	22	24.2	3.1	100%
18	E	30	X	X	32	30	36	32.0	2.8	67%
Number of Resp. Detec.		14	11	14	14	14	14	13.5	1.2	75%

CUMULATIVE TEST DATA SHEET

Fan Speed: medium
No. of Fans: 4
Smoke Source: 50 ml gas
Size or Quan: large pan

Date Prepared: 7/19/83
Data Collected: 7/7 - 7/19

Test # →		9	17B	22	22	24	25	34	35	36	37	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5	6	7	8	9	10			
1	I	18	20	19	24	18	22	26	21	20	18	20.6		100%
2	E	52	69	56	55	42	49	53	90	48	58	57.2	13.5	100%
3	E	64	25	59	59	31	47	46	52	39	47	46.9	12.5	100%
4	I	18	13	17	15	18	18	17	17	16	14	16.3	1.8	100%
5	I	12	13	16	15	14	14	17	14	15	13	14.3	1.5	100%
6	E	18	73	29	25	37	50	46	45	23	25	37.1	16.7	100%
7	I	14	16	16	17	17	21	21	16	16	15	16.9	2.3	100%
8	E	63	83	67	59	61	38	68	50	44	59	59.2	12.8	100%
9	I	95	X	103	86	82	92	X	X	X	X	91.6	8.1	50%
10	E	X	X	X	X	X	X	X	X	X	X	X	X	0%
11	I	56	33	47	65	69	41	64	84	49	61	56.9	14.9	100%
12	E	X	X	X	X	X	X	X	X	X	X	X	X	0%
13	I	59	37	35	62	45	42	36	66	47	33	46.2	12.1	100%
14	E	X	X	X	X	X	X	X	X	X	X	X	X	0%
15	I	48	57	52	61	44	47	62	75	46	39	53.1	--	100%
16	E	X	X	X	X	X	85	X	X	102	X	93.5	12.0	20%
17	I	56	43	57	82	59	59	56	90	36	63	60.1	16.0	100%
18	E	67	81	66	X	72	X	72	X	X	76	72.3	5.6	60%
Number of Resp. Detec.		14	13	14	13	14	14	13	12	13	13	13.3	0.67	73.9%

CUMULATIVE TEST DATA SHEET

Fan Speed: medium
No. of Fans: 1
Smoke Source: 50 ml gas
Size or Quan: large pan

Date Prepared: 7/26/83
Data Collected: 7/22 - 7/26

Test # →		46	47	48	49	50	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5			
1	I	23	17	15	17	15	17.4	3.3	100%
2	E	31	23	43	33	20	30.0	9.1	100%
3	E	35	44	47	26	26	35.6	9.8	100%
4	I	15	15	14	12	12	13.6	1.5	100%
5	I	14	13	12	11	12	12.4	1.1	100%
6	E	26	18	28	15	28	23.0	6.1	100%
7	I	17	16	15	12	16	15.2	1.9	100%
8	E	39	27	36	17	60	35.8	16.0	100%
9	I	72	77	73	60	65	69.4	6.8	100%
10	E	141	X	145	83	92	115.2	32.3	80%
11	I	40	35	33	37	32	35.4	3.2	100%
12	E	X	X	X	X	X	X	X	0%
13	I	38	35	52	28	30	36.6	3.5	100%
14	E	212	X	X	61	52	108.3	89.9	60%
15	I	59	62	46	31	28	45.2	15.6	100%
16	E	X	X	X	51	49	50.0	1.4	40%
17	I	38	32	32	30	25	31.4	--	100%
18	E	X	X	X	41	27	34.0	--	40%
Number of Resp. Detec.		14	13	14	17	17	15.0	1.9	83.3%

CUMULATIVE TEST DATA SHEET

Fan Speed: 0
No. of Fans: 0
Smoke Source: 50 ml gas
Size or Quan: large pan

Date Prepared: 7/19/83
Data Collected: 7/7 - 7/18

Test # →		7	12	26	27	28	29	30	31	32	33	Avg	Std Dev	#RFSR/#
Detector	Code	1	2	3	4	5	6	7	8	9	10			
1	I	16	19	17	14	16	16	13	12	14	13	15.0	2.2	100%
2	E	22	29	25	27	31	43	32	16	40	43	28.2	9.3	100%
3	E	27	29	50	26	50	52	31	27	43	33	36.8	10.7	100%
4	I	12	16	14	11	15	12	11	11	16	11	12.9	2.1	100%
5	I	10	12	16	13	13	14	10	10	11	10	11.9	2.1	100%
6	E	17	25	25	23	32	28	21	24	20	25	24.0	4.2	100%
7	I	15	15	17	18	17	16	12	10	12	14	14.6	2.6	100%
8	E	32	37	48	37	33	50	39	32	34	46	38.8	6.8	100%
9	I	30	66	46	33	28	31	25	42	30	32	36.3	12.2	100%
10	E	116	82	84	56	X	107	77	80	72	80	84.8	17.9	90%
11	I	28	35	40	37	30	38	38	33	27	34	34.0	4.5	100%
12	E	X	55	X	65	X	X	X	63	54	X	59.3	5.6	40%
13	I	29	34	41	58	33	37	32	28	29	35	35.6	8.8	100%
14	E	75	85	68	94	X	X	62	90	79	53	75.8	14.1	80%
15	I	49	56	37	36	45	47	36	47	40	42	43.5	6.5	100%
16	E	98	78	118	54	110	86	113	67	92	129	94.5	23.8	100%
17	I	32	47	26	25	34	25	23	55	31	43	34.1	10.8	100%
18	E	X	77	40	25	X	X	47	X	X	X	47.3	21.9	40%
Number of Resp. Detec.		16	18	17	18	14	15	17	17	17	16	16.5	1.3	92%

Appendix B

EQUIPMENT DESCRIPTION

Fans: Sears 52 inch, three speed ceiling fan, No. 34H 90421L

Photoelectric Smoke Detectors: BRK Electronics, No. 2001, battery powered

Ionization Smoke Detector: BRK Electronics, No. 79R, battery powered

Instrumentation: Honeywell Visicorder.

Appendix C

TEST RUN DESCRIPTION SHEET

Test Run Description Sheet

Test No.	Date	Smoke Source	No. of Fans	Speed
1	6/30	30 sec smoke candle	0	--
2	7/1	30 sec smoke candle	0	--
3	7/6	3 min smoke bomb	0	--
4	7/6	(2) 30 sec smoke candle	0	--
5	7/6	30 sec smoke candle	4	med
6	7/7	50 ml gasoline, small pan	0	--
7	7/7	50 ml gasoline, large pan	0	--
8	7/7	50 ml gasoline, large pan	0	--
9	7/7	50 ml gasoline, large pan	4	med
10	7/7	3 min smoke bomb	0	--
11	7/8	50 ml gasoline, large pan[a]	0	--
12	7/8	50 ml gasoline, large pan	0	--
13	7/12	25 ml gasoline, large pan	0	--
14	7/12	50 ml gasoline, large pan[b]	0	--
15	7/12	25 ml gasoline, large pan[b]	0	--
16	7/12	50 ml gasoline, large pan[b]	0	--
17A	7/12	50 ml gasoline, large pan	4	med
17B	7/12	50 ml gasoline, large pan	4	med
18	7/13	25 ml gasoline, large pan	4	med
19	7/13	25 ml gasoline, large pan	4	med
20	7/16	25 ml gasoline, large pan	4	med
21	7/16	50 ml gasoline, large pan	4	med
22	7/16	50 ml gasoline, large pan	4	med
23	7/16	25 ml gasoline, large pan	4	med
24	7/16	50 ml gasoline, large pan	4	med
25	7/16	50 ml gasoline, large pan	4	med
26	7/18	50 ml gasoline, large pan	0	--
27	7/18	50 ml gasoline, large pan	0	--
28	7/18	50 ml gasoline, large pan	0	--
29	7/18	50 ml gasoline, large pan	0	--
30	7/18	50 ml gasoline, large pan	0	--
31	7/18	50 ml gasoline, large pan	0	--
32	7/18	50 ml gasoline, large pan	0	--
33	7/19	50 ml gasoline, large pan	0	--
34	7/19	50 ml gasoline, large pan	4	med
35	7/19	50 ml gasoline, large pan	4	med
36	7/19	50 ml gasoline, large pan	4	med
37	7/19	50 ml gasoline, large pan	4	med
38	7/20	25 ml gasoline, large pan	4	med
39	7/20	25 ml gasoline, large pan	4	med
40	7/20	25 ml gasoline, large pan	0	--
41	7/20	25 ml gasoline, large pan	0	--

continued

Test Run Description Sheet (Continued)

Test No.	Date	Smoke Source	No. of Fans	Speed
42	7/22	25 ml gasoline, large pan	0	--
43	7/22	25 ml gasoline, large pan	0	--
44	7/22	25 ml gasoline, large pan	0	--
45	7/22	25 ml gasoline, large pan	0	--
46	7/22	50 ml gasoline, large pan	1	med
47	7/22	50 ml gasoline, large pan	1	med
48	7/26	50 ml gasoline, large pan	1	med
49	7/26	50 ml gasoline, large pan	1	med
50	7/26	50 ml gasoline, large pan	1	med
55	7/26	25 ml gasoline, large pan	1	med
56	7/26	25 ml gasoline, large pan	1	med
57	7/26	25 ml gasoline, large pan	1	med
57	7/26	25 ml gasoline, large pan	1	med
59	7/26	25 ml gasoline, large pan	1	med
60	7/26	25 ml gasoline, large pan	1	med
61	8/8	50 ml gasoline, large pan	0	--
62	8/8	50 ml gasoline, large pan	0	--
63	8/8	25 ml gasoline, large pan	0	--
64	8/8	25 ml gasoline, large pan	0	--
65	8/8	50 ml gasoline, large pan	4	med
66	8/8	50 ml gasoline, large pan	4	med
67	8/8	25 ml gasoline, large pan	4	med
68	8/8	25 ml gasoline, large pan	4	med

NOTE: Runs 61 to 68 were conducted with the smoke source in position 2. All others were conducted with the smoke source in Position 1.

[a]Vent open

[b]Half covered

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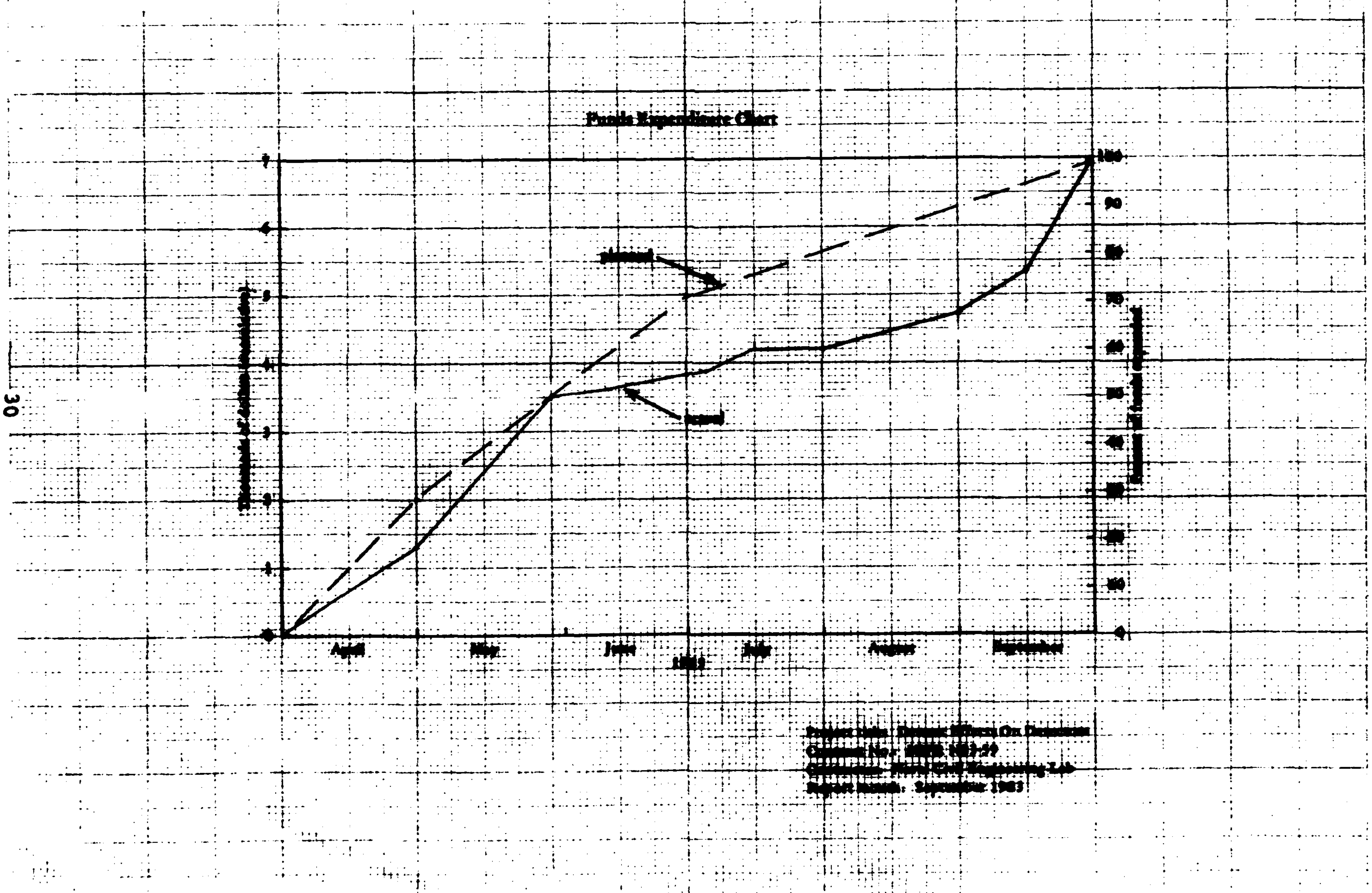
Appendix D

FUNDS EXPENDITURE CHART


Funds Expenditure Chart
Actual
April
May
June
July
August
September
Report Month: September 1983

Appendix E

PERFORMANCE AND COST REPORT

Materials:

(4) Fans	399.96
(4) Fans Mounts	99.96
(4) Fan Extensions	79.96
500 ft Wire (2 cord)	22.30
(100) Wire Connectors	4.14
16 x 100 ft Polyethelene Sheet	77.00
(2) 4 in. by 60 yd Duct Tape	68.00
(1) Ionization Smoke Detectors	143.30
(10) Photoelectric Smoke Detectors	229.30
(4) 50 Extension Cords	25.64
(5) Boxes Smoke Candles	72.00
Construction Material for Partition	132.48
Shipping	18.22
	$1,372.26

Labor:

Facilities Preparation:	
Carpenters	$2,054.00 (56 hrs at $36.68/hr)
Engineers	390.00 (10 hrs at $39/hr)
Test and Evaluation:	
Engineers	$1,560.00 (40 hrs at $39/hr)

Report:

Engineer	$ 858.00 (22 hrs at $39/hr)
Technical Writing and Editing	750.00
	$6,984.26

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